

1 **Air Pollution Reduction and Mortality Benefit during the COVID-19 Outbreak in China**

2 Kai Chen,¹ Meng Wang,² Conghong Huang,² Patrick L. Kinney,³ Paul T. Anastas^{1,4}

3 ¹ Yale School of Public Health, New Haven, CT, USA.

4 ² University at Buffalo School of Public Health and Health Professions, Buffalo, NY, USA.

5 ³ Boston University School of Public Health, Boston, MA, USA

6 ⁴ Yale School of Forestry and Environmental Studies, New Haven, CT, USA.

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8 Corresponding author: Dr. Kai Chen. 60 College Street. New Haven, CT. 06520-8034. Email:

9 kai.chen@yale.edu; Tel: (203)737-7004.

10 Dr. Kai Chen and Dr. Meng Wang contributed equally to this letter.

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14 **LETTER:**

15 To control the novel coronavirus disease (COVID-19) outbreak, China undertook stringent
16 traffic restrictions and self-quarantine measures, first in Wuhan and neighboring cities beginning
17 on January 23, 2020, and two days later, in all provinces in China (Figure 1A). The countrywide
18 ban on traffic mobility greatly limited transportation emissions, whereas emissions from
19 residential heating and industry remained steady or slightly declined.¹ We herein examine the
20 change in air pollution levels and the potentially avoided cause-specific mortality during this
21 massive population quarantine episode.

22 As of March 14, 2020, new confirmed COVID-19 cases in China reported by the National
23 Health Commission (NHC) dropped to 20 (4 from Wuhan) (Figure 1A). Most Chinese provinces
24 have lowered the level of emergency responses. We thus defined the “during quarantine” period
25 as February 10 to March 14 and the “before quarantine” period as January 5 to 20. We excluded
26 the Chinese New Year holidays to avoid non-quarantine related air pollution reductions, based
27 on evidence from previous years (Figure 1B). We obtained daily concentrations of nitrogen
28 dioxide (NO₂) and fine particulate matter (PM_{2.5}) in 367 Chinese cities. We then applied a
29 difference-in-difference approach to quantify air pollution changes due to the quarantine.
30 Specifically, we calculated changes in air quality during vs. before the quarantine period in 2020,
31 and compared these with corresponding changes in the same lunar calendar periods in 2016-
32 2019. Details of the material, methods, and numeric results are provided in the Supplementary
33 Appendix.

34 We found that, due to the quarantine, NO₂ dropped by 22.8 μg/m³ and 12.9 μg/m³ in Wuhan and
35 China, respectively. PM_{2.5} dropped by 1.4 μg/m³ in Wuhan but decreased by 18.9 μg/m³ across
36 367 cities. The dramatic decline in NO₂ across China during the quarantine period was also
37 detected by the Copernicus Sentinel-5P satellite using the NO₂ tropospheric column density
38 (Figure 1C).

39 We then calculated the avoided cause-specific mortality attributable to these decreases in NO₂
40 and PM_{2.5} over China based on the concentration-response functions from a previous study of
41 272 Chinese cities, and the cause-specific mortality data from the China Health and Family
42 Planning Statistical Yearbook 2018.^{2,3} We estimate that improved air quality during the
43 quarantine period avoided a total of 8911 [95 confidence interval (CI): 6950, 10866] NO₂-related

44 deaths, 65% of which were from cardiovascular diseases (hypertensive disease, coronary heart
45 disease, and stroke) and chronic obstructive pulmonary disease (COPD), (Figure 1D). Further,
46 we estimate that PM_{2.5} reductions during the quarantine period avoided a total of 3214 (95% CI:
47 2340, 4087) PM_{2.5}-related deaths in China, 73% of which were from cardiovascular diseases and
48 COPD. These numbers should be interpreted with caution due to the potential overlap between
49 PM_{2.5}- and NO₂-related mortality and the disrupted healthcare systems during quarantine to
50 conduct a timely treatment for patients with chronic diseases.

51 We conclude that interventions to contain the COVID-19 outbreak led to air quality
52 improvements that brought health benefits which outnumbered the confirmed deaths due to
53 COVID-19 in China (3199 deaths as of March 14, 2020).⁴ These findings illustrate the
54 substantial human health benefits related to cardiovascular disease morbidity and mortality that
55 can be achieved when aggressive air pollution control measures are taken to reduce emissions
56 from vehicles, such as through climate mitigation-related traffic restrictions or efforts to
57 accelerate the transition to electric vehicles.

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59 **References**

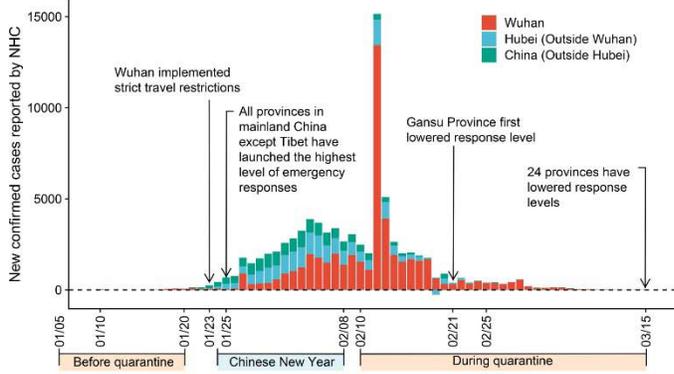
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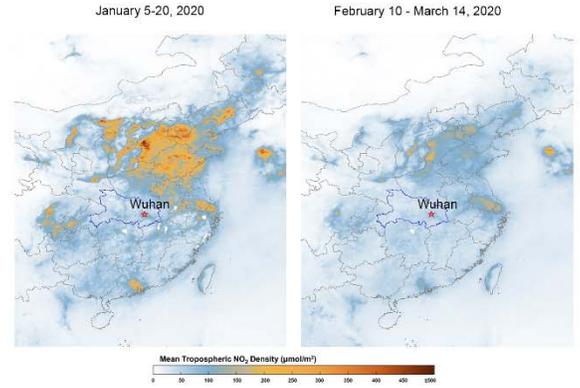
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74 **Figure 1.** Air pollution levels and avoided cause-specific deaths during the COVID-19 outbreak
 75 in China.

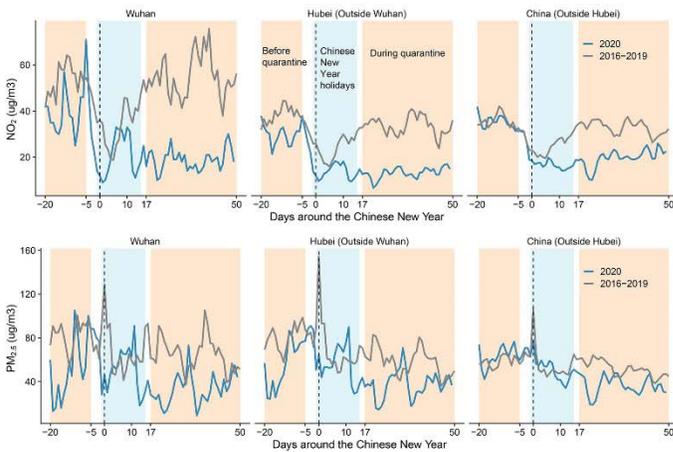
A COVID-19 and quarantine measures in China



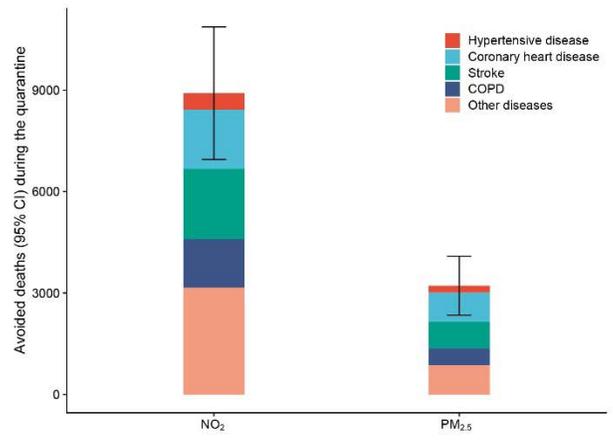
C NO₂ density changes during vs. before the quarantine



B Air pollution levels in China before and during the quarantine



D Avoided deaths due to air pollution reduction during the quarantine



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